Geosynthetics in Transportation Facilities

by

Geosynthetic Institute
475 Kedron Ave.
Folsom, PA 19033, USA
Phone: (610) 522-8440
Fax: (610) 522-8441
robert.koerner@coe.drexel.edu

Course Outline

1.0 Background and Overview
2.0 Roadway Separation/Reinforcement
3.0 Soil Reinforcement (Slopes, Embankments and Walls)
4.0 Filtration and Drainage
5.0 Other Transportation Applications
6.0 Concerns and Needs
7.0 Closing Remarks

1.0 Background and Overview

1.1 Types of Geosynthetics
1.2 Design Methods
1.3 Test Methods
1.4 Design Models
1.5 Factor-of-Safety (FS) Comments

1.1 Types of Geosynthetics (GS)

- Geotextiles (GT)
- Geogrids (GG)
- Geonets (GN)
- Geomembranes (GM)
- Geosynthetic Clay Liners (GCL)
- Geopipe (GP)
- Geocomposites (GC)

1.2 Design Methods

- Design-by-Cost
- Design-by-Specification
- Design-by-Function

Design-by-Cost

- fast, and easy, method
- one must accept the possibility of poor performance or even failure
- not acceptable for permanent, or critical, systems
- complicated by the wide range of available products in every geosynthetics category

Design-by-Specification

- acceptable for routine applications:
  - highway filters
  - filters beneath rip-rap
  - silt fences
  - roadway separation
  - railroad separation
- most state specs are of this type
- needs large data base of both successes and failures
- difficult to establish cut-offs
- tends to go toward low end values
- AASHTO's M288 is a major advance in GT specifications… details follow

(a) AASHTO M288-00
Geotextile Installation Survivability Requirements

	Test	Units	Geotextile Classification[1]					
			Class 1		Class 2		Class 3	
			W	NW	W	NW	W	NW
Grab Strength	ASTM D4632	N	1400	900	1100	700	800	500
Sewn Seam Strength[3]	ASTM D4632	N	1200	810	990	630	720	450
Tear Strength	ASTM D4533	N	500	350	400[4]	250	300	180
Puncture Strength	ASTM D4833	N	500	350	400	250	300	180
Permittivity	ASTM D4491	sec^{-1}	Minimum property requirements for permittivity. AOS and UV stability are based on geotextile application. Refer to Table (b) for subsurface filtration. Table (c) for separation, Table (d) for stabilization, Table (e) for permanent erosion control, Table (f) for silt fence, and Table (g) for reflective cracking					
Apparent Opening Size	ASTM D4751	mm						
Ultraviolet Stability	ASTM D4355	%						

(b) Filtration Specification

		% Passing 0.075 mm Sieve		
		< 15	15 to 50	> 50
Class		Class 2		
permittivity	s^{-1}	> 0.5	> 0.2	> 0.1
AOS	mm	< 0.43	< 0.25	< 0.22
UV	%	> 50% ret. after 500 hours		

(c) Separation Specification

Class		Class 2
permittivity	s^{-1}	> 0.02
AOS	mm	< 0.60
UV	%	> 50

(d) Stabilization Specification

Class		Class 1
permittivity	s^{-1}	> 0.05
AOS	mm	< 0.43
UV	%	> 50

(e) Erosion Control Specification

		% Passing 0.075 mm Sieve		
		< 15	15 to 50	> 50
Class		for wovens 2; for nonwovens 1		
permittivity	s^{-1}	> 0.7	> 0.2	> 0.1
AOS	mm	< 0.43	< 0.25	< 0.22
UV	%	> 50	> 50	> 50

(f) Silt Fence Specification

		supported	unsupported	
		NW or W	NW	W
post spacing	m	1.2	1.2	2.0
grab MD	N	400	550	550
XMD	N	400	450	450
permittivity	s^{-1}	> 0.05	>0.05	> 0.05
AOS	mm	< 0.60	< 0.60	< 0.60
UV	%	> 50	> 50	> 50

(g) Reflective Cracking Specification

grab	N	≥ 450
mass	gm/m^2	≥ 140
elong.	%	≥ 50
asph. ret.	l/m^2	varies
Melting	°C	≥ 150

Design-by-Function

1. predetermine the required FS
2. assess primary function
3. determine required property value
4. measure allowable property value
5. calculate the resulting FS and compare to required
6. challenge realism of result

The Essential Equation is:

$$FS = \frac{\text{Allow. (Test) Property}}{\text{Reqd. (Design) Property}}$$

- Test Methods from ASTM, ISO, CEN or GRI (depends on availability or country)
- Design Models from the literature
- FS > 1.0 is for uncertainties in testing and/or design

The Primary Functions of GS

- **Separation**
  - separating dissimilar materials so both can function optimally
- **Reinforcement**
  - providing tensile strength to soils (usually)
- **Filtration**
  - allowing cross-plane flow, yet retaining upstream particles
- **Drainage**
  - providing in-plane flow, yet retaining upstream particles
- **Barrier (or Containment)**
  - preventing liquids, gases, or solids from becoming fugitive

Functions Provided by Geosynthetics

Type	Sep.	Reinf.	Filter	Drain	Barrier
GT	Yes	Yes	Yes	Yes	–
GG	–	Yes	–	–	–
GN	–	–	–	Yes	–
GM	–	–	–	–	Yes
GCL	–	–	–	–	Yes
GP	–	–	–	Yes	–
GC	d.o.t.	d.o.t.	d.o.t.	d.o.t.	d.o.t.

Note: d.o.t. = depends on type

1.3 Test Methods

- ASTM Committee D-35 (approx. 50 standards)
- Subcommittees
  - Mechanical
  - Hydraulic
  - Endurance
  - Geomembranes
  - Geosynthetic Clay Liners
- Index test status - good
- Performance test status- difficult and slow to develop
- ISO & CEN standards available
- GRI Standards are also available (approx. 45 standards)

GRI Standards*

- Geotextiles (8 Stds)
- Geogrids (6 Stds)
- Geonets (1 Std)
- Geomembranes (15 Stds)
- Geosynthetic Clay Liners (2 Stds)
- Geocomposites (8 Stds)
- Geosynthetics (7 Stds)

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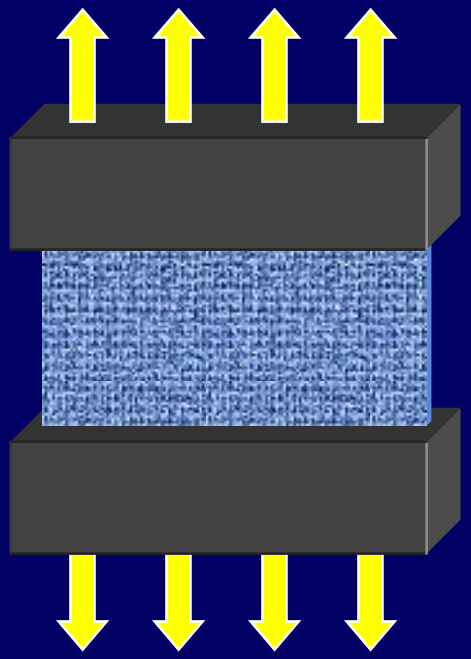
* For use by everyone until ASTM or ISO develops a test method on the similar subject; then the GRI Method is discontinued

Major Design-Related Tests

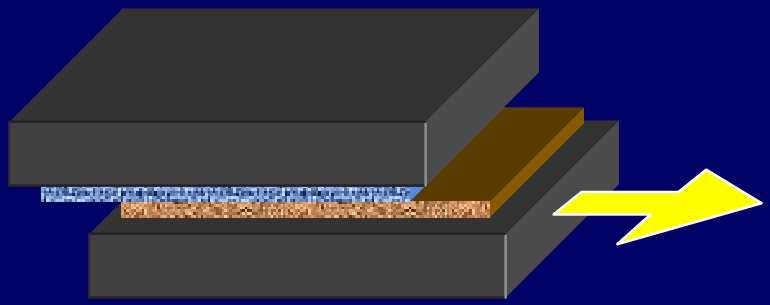
(a1) Mechanical Test - Wide-width tension



ASTM D4595

Major Design-Related Tests *(cont'd)*

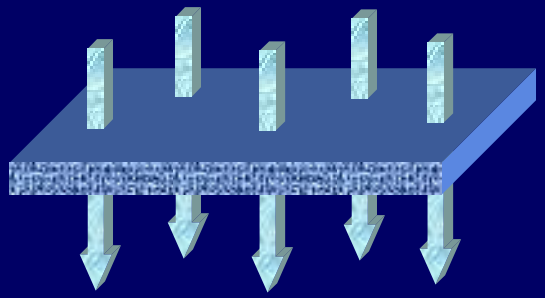
(a2) Mechanical Test - Direct shear



ASTM D5321

Major Design-Related Tests *(cont'd)*

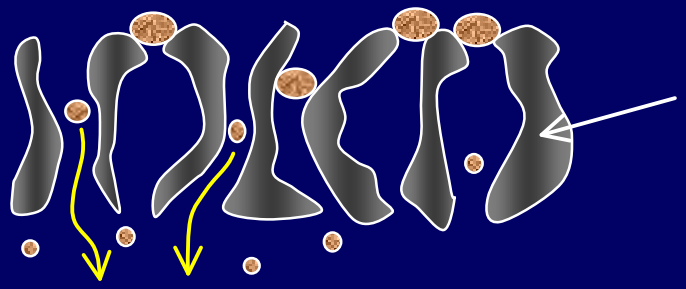
(b1) Hydraulic Test - Permittivity



ASTM D4491

Major Design-Related Tests *(cont'd)*

(b2) Hydraulic Test - apparent opening size



ASTM D4751

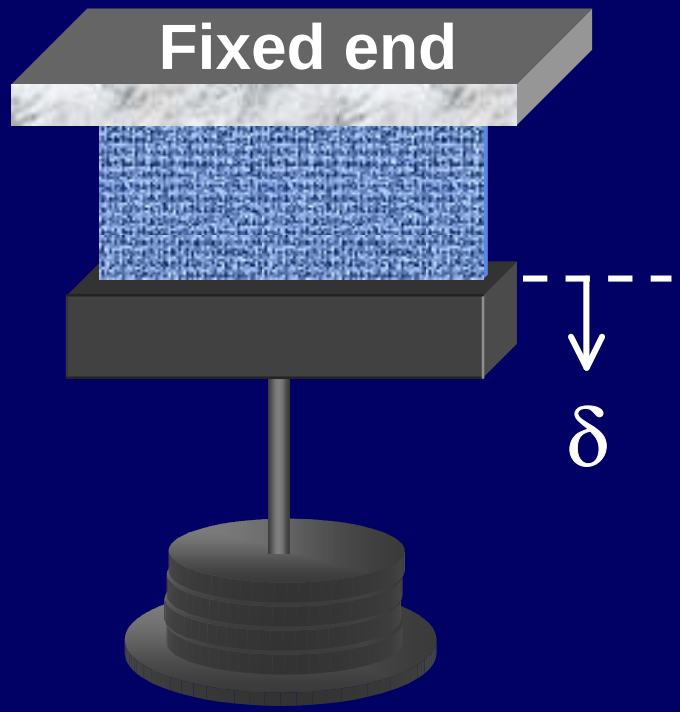
Major Design-Related Tests *(cont'd)*

(b3) Hydraulic Test - transmissivity

ASTM D4716

Major Design-Related Tests *(cont'd)*

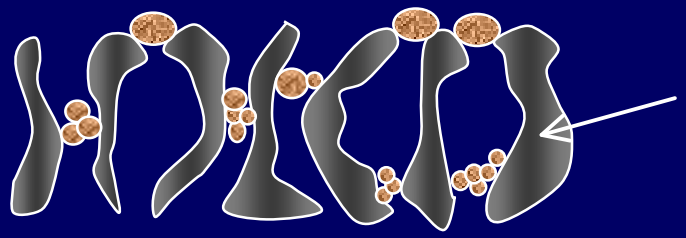
(c1) Endurance Test - Creep



ASTM D5262

Major Design-Related Tests *(cont'd)*

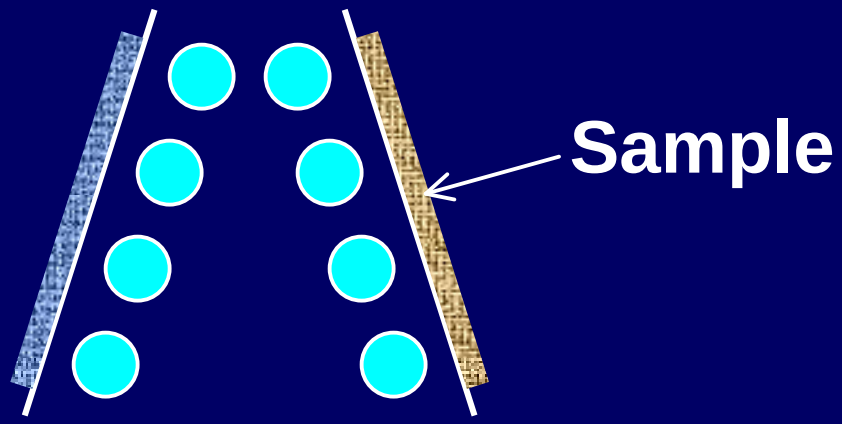
(c2) Endurance Test - Excessive clogging



ASTM D5101 or D5567

Major Design-Related Tests *(cont'd)*

(c3) Endurance Test - Ultraviolet exposure



ASTM D4355 or G26

Reduction Factors

- **Concept - modify an index test value to obtain a site specific performance value**

$$\text{Property}_{(\text{allow})} = \text{Property}_{(\text{test})} \left[\frac{1}{RF_1 \times RF_2 \times \ldots} \right]$$

where

RF_i = those details not included in the lab test

- **Currently used for strength and flow problems**
- **Not used on containment problems (i.e., liners and related barriers)**

1.4 Design Models

- Utilize geotechnical, hydraulic or environmental engineering concepts
- Typically draw free body diagram, then limit equilibrium
- Viscoelasticity is sometimes considered via strain compatibility
- Finite element methods just beginning
- Judgment (i.e., empiricism) still required, but models are improving rapidly

1.5 Factor-of-Safety Comments

Time →	Temporary	Permanent
↓Severity		
Noncritical	moderate	high
Critical	high	very high

Assuming that RF's have been used on ultimate lab values:

- separation 1.2 to 2.5
- reinforcement 1.4 to 2.0
- filtration 3 to 10+
- drainage 3 to 10+
- barrier problem specific

End of Section-1